**Section 960**

# GUIDELINES FOR SUPERPAVE VOLUMETRIC MIX DESIGN AND VERIFICATION

## 960.01 Scope

This procedure provides guidelines to determine a Superpave Volumetric Mix Design for Hot-Mix Asphalt (HMA) for incorporation into Department projects. The Contractor will perform and submit the mix design according to specification; the Department will verify the mix design.

**REFERENCES**:

AASHTO STANDARDS:

M 323 Superpave Volumetric Mix Design

R 30 Standard Practice for Mixture Conditioning of Hot-Mix Asphalt (HMA)

R 35 Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt (HMA)

T 30 Mechanical Analysis of Extracted Aggregate

T 84 Specific Gravity and Absorption of Fine Aggregate

T 85 Specific Gravity and Absorption of Coarse Aggregate

T 166 Bulk Specific Gravity of Compacted Hot-Mix Asphalt Mixtures Using Saturated-Surface Dry Specimens

T 209 Theoretical Maximum Specific Gravity and Density of Hot-Mix Paving Mixtures

T 308 Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method

T 312 Standard Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

T 319 Quantitative Extraction and Recovery of Asphalt Binder from Asphalt Mixtures

TP 62 Determining Dynamic Modulus of Hot-Mix Asphalt Concrete Mixtures

UDOT MATERIALS MANUAL OF INSTRUCTION (MOI) PART 8

UDOT MINIMUM SAMPLING AND TESTING REQUIREMENTS

UDOT STANDARD SPECIFICATIONS

UDOT PROJECT SPECIAL PROVISIONS

## 960.02 Significance and Use

The objective of HMA mix design is to determine the combination of asphalt binder and aggregates that will give long lasting performance as part of the pavement structure. Mix design involves laboratory procedures developed to establish the necessary proportion of materials for use in HMA. Well-designed asphalt mixtures can be expected to serve successfully for many years.

The mix design of HMA is just the starting point to assure that an asphalt concrete pavement will perform as required. Together with proper construction practice, mix design is an important step in achieving well-performing asphalt pavements. In many cases, the cause of poorly-performing pavements has been attributed to poor or inappropriate mix design or to the production of a mixture other than what was designed in the laboratory. To that end, it is critical that the materials and proportions used in the design are representative of the materials and proportions that will be used in the pavement structure.

The purpose of the Mix Design Verification Process is to provide an independent review of the Contractor's mix design. The verification process may consist of any, or all of the following:

- A review of the Contractor's design submittal documentation
- A review of the project history of a previously used HMA design
- A duplication of the Contractor's laboratory effort to verify individual mix components and/or total mix properties.

## 960.03 Superpave Volumetric Mix Design Guidelines

The mix design shall comply with *AASHTO M 323; Standard Specification for Superpave Volumetric Mix Design* with the following modifications:

Asphalt binder, aggregate and mix properties are defined by project specification, including, but not limited to:

- Dust-to-binder ratio
- VMA
- VFA
- Design air void content ($V_a$) (% compaction @ $N_{des}$)

- PG asphalt binder grade
- RAP asphalt binder recovered by AASHTO T 319
- Hamburg Wheel-Track Testing (MOI 990) - (replaces Tensile Strength Ratio (Lottman))
- Flakiness Index (MOI 933) – (replaces Flat and Elongated Particles)

The laboratory performing the mix design will be qualified in HMA by the Laboratory Qualification Program. Personnel must be qualified in Transportation Technician Qualification Program (TTQP) Asphalt (AsTT) and Superpave Mix Design (SMD)

The compactor will be approved as per MOI 8-961; Guidelines for Superpave Gyratory Compactor Protocol.

## 960.04 Standard Practice for Superpave Volumetric Mix Design

Mix Designs will be performed in accordance with *AASHTO R 35: Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt* with the following modifications:

- Replace $G_{sb}$ with $G_{sb}$SSD in VMA calculations.

- Target air void content ($V_a$) is by project specification.

The mix design will be performed using materials intended for use on the project. Materials used in the mix design will meet the following criteria:

- **Asphalt binder** shall be obtained from a certified supplier meeting the requirements outlined in the UDOT *Quality Management Plan 509; Asphalt Binder Management System*. For mix design verifications, the Region Labs will obtain pre-qualified binder from the UDOT Binder Lab.

- **Hydrated lime** shall be obtained from a certified supplier meeting the requirements outlined in *Quality Management Plan 510: Hydrated Lime Management System.* The hydrated lime will be accompanied by test results or will be pre-tested by the Central Materials Laboratory prior to use in the mix design verification.

Requirements when using recycled asphalt pavement (RAP):

- Percentage of RAP in the mix design will be expressed as a percentage of the final mix.

- For mix designs that incorporate more that 15 percent RAP, a test report will be provided for each stockpile of RAP that includes: gradation, aggregate properties, asphalt binder content and PG grade of extracted asphalt binder (AASHTO M 323)

- The final aggregate gradation is determined after the RAP and hydrated lime are added. (AASHTO T 30)

The HMA is mixed according to MOI 8-988. Mixed material will be aged for "Volumetric Mix Designs" as per AASHTO R 30.

After the mix design parameters are determined, prepare and compact four sets of two gyratory specimens. Compact three sets to $N_{des}$ to verify the target air voids, as defined by UDOT Standard Specification 02741, ±0.5% at optimum asphalt binder content. Compact one set to $N_{max}$ to verify required relative density. AASHTO T 312

The Region Materials Laboratory will perform Hamburg Wheel Track Testing of Compacted Bituminous Mixtures (MOI 990). Refer to 960.05 for material submittal.

## 960.05 Mix Design Verification Process

**General:**

The Department performs mix design verification; the verification process outlined in this document is intended to be complete. However, verification could include any or all tests identified in AASHTO M 323, project specifications, project special provisions, the current MOI, the current *Minimum Sampling and Testing Requirements* or other aggregate quality, volumetric, or mix performance tests that may be added in the future. All materials submitted for use in the verification process are required to be representative of those used in the mix design.

The Contractor will submit the volumetric mix design data and materials samples for verification at least 10 working days before beginning paving. Paving will not begin until verification is complete. "Working days" refer to Monday through Friday, excluding state holidays, and begin when all the following are submitted to the Region Laboratory:

- Mix Design Report
- *All* aggregate quality test results
- *All* pre-blended aggregate samples
- A *sufficient quantity* of the hydrated lime
- A *sufficient quantity* of the RAP used during the mix design process
- Test Report for RAP
- Test Report for hydrated lime
- Asphalt binder to Central Materials Lab

"Working days" end when the Region Materials Engineer (RME) provides a **Mix Design Review Report** to the Resident Engineer.

## 960.05.01 Contractor Submittals

**Mix Design Report** - The Contractor will submit the Mix Design Report to the RME. The Contractor will submit a Mix Design Report Summary and Transmittal Letter to the Resident Engineer (RE). The submittals should follow the outline and example in Appendix "A."

A verified mix design may be submitted for use on a project other than the project originally identified. The Contractor will submit the Verified Mix Design Report to the RME and a Mix Design Report Summary and Transmittal Letter to the RE for the new project. **Both reports must include documentation regarding field changes made after original verification.**

**Pre-Blended Samples** - The Contractor will prepare samples for use in the verification process. The pre-blended samples, RAP, and hydrated lime are submitted to the RME. The Contractor will provide additional samples upon request.

***Note:*** Asphalt binder for mix design verification will be supplied to the Region Materials Lab from Central Materials Lab.

A pre-blended sample is a blend of the final aggregate structure, without RAP, hydrated lime, and asphalt binder. Pre-blended samples are made at the required sample size by recombining the aggregate portion that has been sieved into individual sieve size fractions. Larger samples split to sample size are not acceptable.

The final gradation of the mix includes the RAP and hydrated lime, as per specification. Mix design verification may include a sieve analysis of the virgin materials and/or of the post-ignition final gradation.

The following tolerances from target gradation for each sieve will be allowed:

| | |
|---|---|
| 1/2 inch | 2% |
| 3/8 inch | 2% |
| No. 4 | 2% |
| No. 8 | 1% |
| No. 16 | 1% |
| No. 30 | 1% |
| No. 50 | 1% |
| No. 100 | 1% |
| No. 200 | 0.8% |

**Initial pre-blended samples to be submitted:**

**11 Samples – Gyratory Compaction – AASHTO T 312**

**5 Samples – $G_{mm}$ Determination – AASHTO T 209**

**2 Samples – Hamburg Wheel Track Testing – MOI 8-990**

- Prepared as above (not mixed)

**5 Samples – Dynamic Modulus – AASHTO TP 62**

**Samples to be submitted after the mix is verified:**

**4 Asphalt Binder Correction Samples per ignition oven**, **AASHTO T 308**
Samples are submitted at mix design binder content and gradation: blend the final aggregate structure with hydrated lime, RAP, and asphalt binder according to MOI 8-988 prior to submitting.

## 960.05.02 Verification Process

The following information will be evaluated on the submitted Mix Design:

**Volumetric Calculations**

**Air Voids**

**Asphalt Binder Grade**

**Gyratory Compaction Effort ($N_{values}$)**

**VMA**

**VFA**

**Aggregate Quality Tests**

**Hydrated Lime**

**Gradation:**

- The gradation will be evaluated for compliance with the specifications.
- The stockpile gradations and blending percentages must be submitted and may be verified by the Region and compared to the submitted data.

**The following tests may be performed on submitted material during the verification procedure.** The Region materials laboratory will obtain appropriate asphalt binder for mix design verification from the Central Materials Laboratory. For tests performed on the HMA, the submitted material will be mixed according to MOI 8-988 and aged for "Volumetric Mix Designs" according to AASHTO R 30.

**$G_{mb}$** – determined on 3 sets of 2 gyratory specimens compacted to $N_{des}$ – AASHTO T 312 and T 166

**$\%G_{mm}$ at $N_{max}$** – determined on 1 set of 2 gyratory specimens compacted to $N_{max}$ – AASHTO T 312 and T 166

**$G_{mm}$** – AASHTO T 209

**Final mix gradation** – AASHTO T 30

**$G_{sb}$ SSD** – fine and coarse aggregate specific gravities – AASHTO T 84 and T 85

Refer to the "Precision and Bias" statement of the AASHTO procedure for acceptable multi-laboratory precision.

Any or all of the quality verification tests may be revisited during production. If any of the aggregate quality tests do not meet the specified criteria, production shall be halted and the issue addressed.

### 960.05.03 Mix Design Performance Testing

**Hamburg Wheel Track Testing of Compacted Bituminous Mixtures MOI 8-990** is a mix design requirement performed by the Region Materials Laboratory after a mix has been verified. The Region Lab will obtain appropriate asphalt binder from the Central Materials Laboratory.

### 960.05.04 Mix Design Re-Verification:

The RME may choose to approve a previously verified mix design through a review of documentation of the original verification process. The documentation must include results of Hamburg testing. The RME may also require project performance data from use on previous projects.

- The RME may elect to require re-verification of Hamburg Wheel Tracker performance.

The RME will re-evaluate any mix design(s) at any indication of significant changes to the total mix properties and/or any individual component. A complete re-evaluation of HMA mix designs will occur at a minimum of every two years.

### 960.05.05 Field Mix Design Verification:

The RME may allow a field verification option of the mix design. The Region or Satellite Lab performs the tests for field verification on material placed on an independent test strip outside of the project limits. The verification laboratory is required to perform an

ignition oven calibration prior to field mix design verification in order to determine an accurate field asphalt binder content for volumetric calculations.

To verify the mix design, determine that the volumetric properties at $N_{des}$ meet project specifications. The following tests are performed on samples obtained in accordance with MOI 8-984, and reduced in accordance with MOI 8-985.

**$G_{mb}$** – determined on a minimum of 3 sets of 2 gyratory specimens compacted to $N_{des}$ – AASHTO T 312 and T 166

**$\%G_{mm}$ at $N_{max}$** – determined on a minimum of 1 set of 2 gyratory specimens compacted to $N_{max}$ – AASHTO T 312 and T 166

**$G_{mm}$** – AASHTO T 209

**% Asphalt Binder Content** – AASHTO T 308

**Gradation of residual aggregate** – AASHTO T 30 – performed on the $G_{mm}$ sample

**Hamburg Wheel Track Testing of Compacted Bituminous Mixtures –** MOI 990

Should the test results not meet specification the supplier may make adjustments and the process repeated. The mix design is "Not Verified" if test results fail to meet specification after the second attempt.

## 960.06 Mix Design Review Report

After the verification process is complete, the RME will provide a written summary report to the RE as notification of the results. The Mix Design Review Report will indicate whether the mix design has been:

- **Verified as Submitted**
- **Verified with Conditions**
- **Not Verified**

Results of **"Verified with Conditions"** and **"Not Verified"** will include an explanation of conditions and/or deficiencies.

The Mix Design Review Report will also contain a summary of the region laboratory test results and necessary construction information. Appendix "B" shows an example of information contained in the Mix Design Review Report.

**APPENDIX "A"**
INFORMATION OUTLINE FOR CONSULTANT / CONTRACTOR
MIX DESIGN REPORT

**First Two/Three Pages of Design Submitted Shall Include the Following Mix Design Information:**

X Date:
X Laboratory Name:
    Accreditation / Credentials (AMRL/UDOT approved)
X Laboratory Technicians :
    Credentials (UDOT certified)
X UDOT Project Name & Number:
X Nominal Gradation Size:
X Number of Gyrations:
    $N_{ini}$, $N_{des}$, $N_{max}$
    Corresponding ESAL Loading Range
X Gyratory Compactor:
    Brand / Model
X Asphalt Binder:
    PG Grade
    Asphalt binder Source
    Asphalt binder Specific Gravity
X Recycled Asphalt Pavement (RAP) if used:
    Gradation
    PG Grade
    % Asphalt Binder Content
    % Virgin Asphalt Binder used to achieve final asphalt binder content
    % RAP used in mix
X Measured Physical Properties
    Design Mixing Temperature
    Design Compaction Temperature
    % Asphalt Binder Content @ $N_{des}$
    % Absorbed Asphalt Binder @ $N_{des}$
    % Effective Asphalt Binder @ $N_{des}$
    % VMA @ $N_{des}$ (Percent by Weight of Total Mix)
    % VFA @ $N_{des}$
    % Compaction @ $N_{ini}$
    % Compaction @ $N_{des}$
    % Compaction @ $N_{max}$
    Dust to Asphalt Binder Ratio @ $N_{des}$
    Maximum Specific Gravity @ $N_{des}$
    % Hydrated lime Required
    Bulk Specific Gravity $G_{sb}$
    Maximum Specific Gravity $G_{mm}$
    Target Gradation
X Proof Testing - (Specification Dependent)
    Hamburg Wheel Tracker
X Aggregate
    One Fracture Face Count
    Two Fracture Face Count
    Fine Aggregate Angularity
    Flakiness

L.A. Wear
Sand Equivalency (Pre-wet Method)
Natural Fines %

X Additional Aggregate Source Information
Sodium Soundness
Unit Weight
Clay Lumps & Friable Particles
Plasticity Index

X Gradation
Stockpile Percentages
Stockpile Specific Gravities & Absorptions
Hydrated lime Specific Gravity & Percentage & Supplier
Target Gradation
Plotted Gradation (0.45 power curve, control points, caution zone)

X Gyratory Design
Calibrated Gyratory Angle
Calibrated Gyratory Pressure
Specimen Heights

**Reported Elsewhere in the Submittal:**

X Trial Blend
Plotted on 0.45 Power Curve (Control Points, Caution Zone)
Stockpile Percentages
Stockpile Bulk Specific Gravities
Target Gradations
%AC, $\%G_{mm}$ @ $N_{ini}$, $\%G_{mm}$ @ $N_{des}$, $\%G_{mm}$ @ $N_{max}$ (Sum.Table)
%AC, % Air Voids, %VMA, %VFA, Dust/Asphalt Binder , $\%G_{mm}$ @ $N_{ini}$, $\%G_{mm}$ @ $N_{des}$, $\%G_{mm}$ @ $N_{max}$ (Summary Table @ $N_{des}$)
Trial Blends
AC Percentage
Compaction Results
$N_{ini}$ - $N_{des}$ - $N_{max}$
Maximum Specific Gravity $G_{mm}$
Gyratory Equipment Printouts for all Blends
Specimen Heights
Pressure Applied
Gyration Tables for Each Design AC Content
Number of Gyrations
Specimen Height
Estimated Bulk Density
Corrected Bulk Density
% of Maximum Specific Gravity

**APPENDIX "B"**

# *Memorandum*

***UTAH DEPARTMENT OF TRANSPORTATION***

DATE:

TO:
Resident Engineer

FROM:
Region Materials Engineer

SUBJECT: Superpave Level I Mix Design Review Report
Project No.:
Project Name:
Contractor:

For the above referenced project, the contractor has indicated that their HMA supplier will be ____, and will be produced at the _____ plant.

Nominal Maximum Aggregate Size _____
Aggregate Source _____
Asphalt Binder Grade and Brand _____
Gyratory Compactive Effort
$N_{ini}$ _____ **$N_{des}$**_____$N_{max}$ _____

Based upon a Volumetric Mix Design the following represents the design aggregate structure and optimum asphalt binder content for the required Superpave compactive effort.

The field specimen compaction temperature is **_____** and the combined specific gravity ($G_{sb}$SSD) of aggregates is**_____**.

Asphalt Binder Grade:**_____** **Stockpile Blends:**
Percentage Asphalt Binder:**____**
**RAP percent Asphalt Binder**
**Virgin % Asphalt Binder** _____
Mixing Temperatures: _____
**Minimum**_____ _____
**Maximum**_____ _____
Minimum Compaction Temperature_____ _____

CONTRACTOR'S DESIGN RESULTS:

Hydrated Lime % (Dry Wt. Agg.):

VMA:

Max. Specific Gravity (Rice):

Voids at $N_{des}$:

Pavement Analyzer Results:

Burn-off Correction Factor:
Field:
Region:

| Sieve | Job Mix Gradation % Passing |
|---|---|
| 1 inch | |
| 3/4 inch | |
| 1/2 inch | |
| 3/8 inch | |
| No. 4 | |
| No. 8 | |
| No. 16 | |
| No. 30 | |
| No. 50 | |
| No. 100 | |
| No. 200 | |

**Contractor's Superpave Mix Design Was: (See Box Checked Below)**

**Verified As Submitted** **Verified With Conditions** **Not Verified for Following Reasons**

**Comments/Conditions/Reasons:_____**